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Silent pirates: *Anolis sagrei* Duméril & Bibron, 1837 (Squamata, Dactyloidae) taking over Panama City, Panama

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Abstract
Anolis sagrei Duméril & Bibron, 1837 is one of the most widespread reptiles in the world, having colonized more than 15 countries on 2 continents. It inhabits open areas and is commonly found around big cities. We noticed the presence of an unreported, nonnative population in Panama City, Panama, which has been established since at least 5 years. We report *Anolis sagrei* for the first time in Panama based on collected specimens. We argue that the species is currently abundant in some areas and it could be a threat for native species.

Keywords
Alien species, invasive species, new country record.

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Introduction

Panama City has a long history of transit and has played an important role in the worldwide commercial trade (Osorio 2016, Parker 2009). Nowadays, there are no pirates, but the continued traffic through the Panama Canal (PC) has provided a means of transport and colonization of invasive flora and marine fauna in and around the canal (Hammond 1998, Ros et al. 2014). However, there is a lack of scientific evidence that terrestrial fauna have colonized the country through the PC (Crawford et al. 2011). Although, there are colonization records of exotic frogs and nocturnal geckos into Panama, hypothesized to be attributable to the PC ship traffic (Crawford et al. 2011, Ibáñez and Rand 1990, Smith and Grant 1961), but no diurnal lizards have been documented until now. Here we report for the first time the colonization of Panama by an alien lizard, *Anolis sagrei* Duméril & Bibron, 1837 which may have been established for as long as a decade.

Anolis sagrei is one of the most widespread anoline lizards in the world. It has been recorded from 2 continents (America and Asia) and more than 15 insular and continental countries in the Americas (Amador et al. 2017, Lee 1996, Norval et al. 2012, Tan and Lim 2012). The species is native to Cuba and the surrounding islands (Williams 1969), and was recorded for the first time outside its natural distribution in Florida Keys, United States (Garman 1887). In Mesoamerica, the species has been reported in Mexico, Belize, and Costa Rica (Köhler 2008, Lee 1996). This species is well adapted to urban areas, and the biological requirements are very

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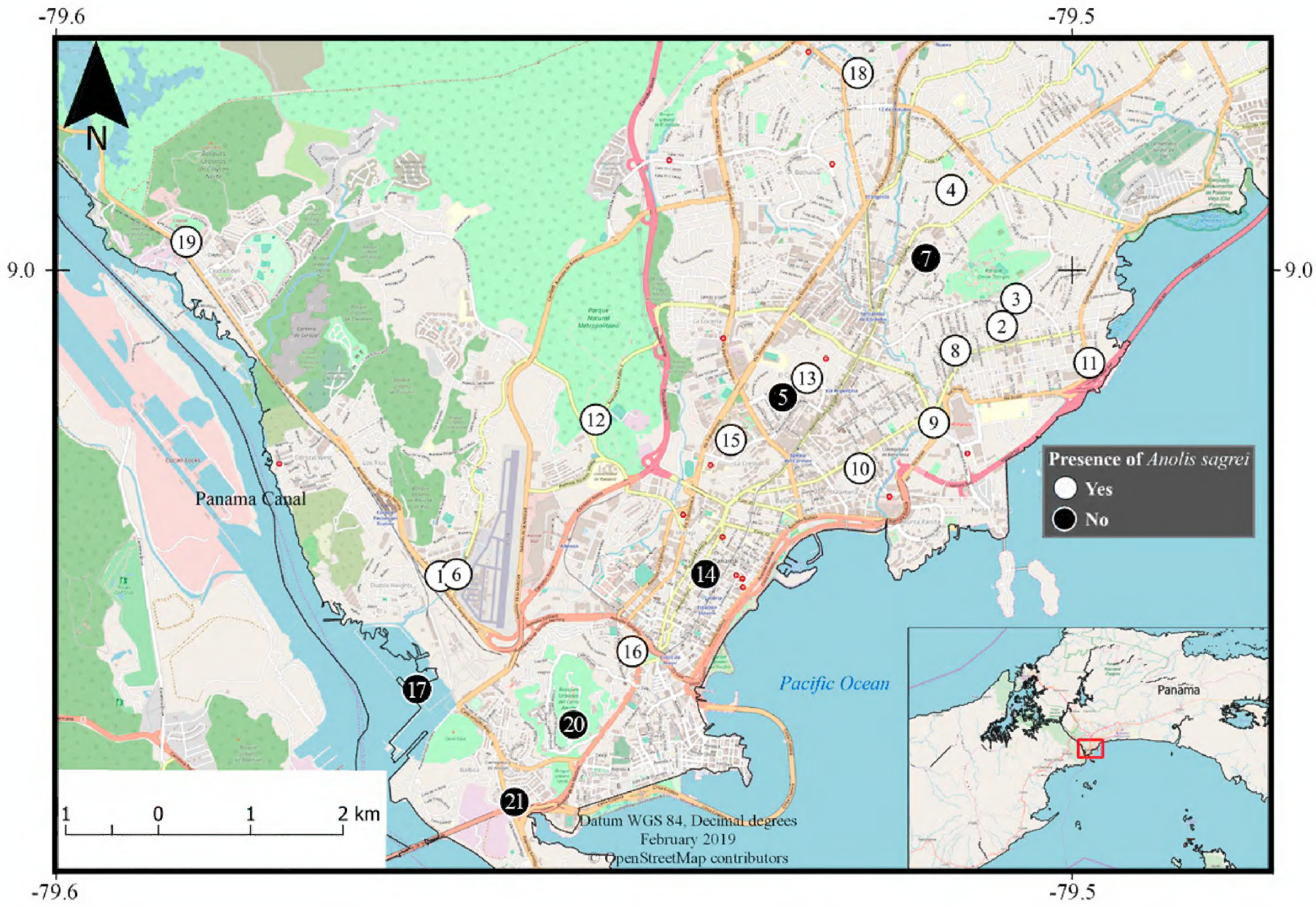

Figure 1. Distributional map of *Anolis sagrei* in Panama City, Panama. Open circles indicate presence and close circles absence of *A. sagrei*. Numbers correspond to those localities shown in Table 1.

low. Therefore, there are populations living in small patches of bushes in gardens around big cities (Amador et al. 2017). *Anolis sagrei* has fast reproductive cycle and ontogenetic development, females can lay an egg every 10 days, and one-month old juveniles may be reproductively mature (Lee et al. 1989). Due to these fast reproductive cycles, colonizing new and urban areas should not be difficult for this species (Amador et al. 2017, Tan and Lim 2012, Williams 1969). Additionally, it can easily adapt to new environments to feed and avoid predators (Kenny et al. 2017, Lapiedra et al. 2018, Schoener et al. 2017). Herein, we report the presence of *A. sagrei* for the first time in Panama City, Panama, with photographic evidence and collected specimens, and discuss the potential impact of this invasive lizard on native species.

Methods

On 26 March 2018, we received a photograph from the Director of the Audubon Society Panama, R. Miro, of an anole near the Panama Railway Company at Albrook (Fig. 1; 08.9699° N, 079.5622° W). The photo showed a courting pair of anoles on the border of a plantation of ornamental ferns (Fig. 2A). A month later, we received another photo from an ornithologist, R. Jordan, of an anole from 50th Street, downtown Panama City (08.9805° N, 079.5209° W), one of the most used roads in the city (Figs 1, 2). We went to those locations and confirmed the presence of the non-native *Anolis sagrei*.

Table 1. Geographic coordinates used in this study. Localities correspond to those shown on Figure 1, with presence or absence of *Anolis sagrei*, for the surveyed areas in Panama City.

#	Locality	Coordinates		Presence
		°N	°W	
1	Albrook	08.9699	079.5622	Yes
2	73th Street	08.9945	079.5069	Yes
3	Parque Recreativo Omar	08.9972	079.5055	Yes
4	Hato Pintado	09.0079	079.5119	Yes
5	53th Street	08.9875	079.5285	No
6	UDELAS	08.9701	079.5606	Yes
7	66th Street	09.0012	079.5144	No
8	67th E Street	08.9921	079.5115	Yes
9	50th Street	08.9850	079.5136	Yes
10	50th Street	08.9805	079.5209	Yes
11	Around Atlapa CC	08.9909	079.4983	Yes
12	Metropolitan Park	08.9853	079.5469	Yes
13	Andres Bello Park	08.9894	079.5261	Yes
14	Fransisco A. Paredes Park	08.9701	079.5361	No
15	Univerity of Panama	08.9833	079.5336	Yes
16	STRI, Tupper, 5 de Mayo	08.9625	079.5433	Yes
17	Balboa Port	08.9588	079.5645	No
18	Guayacanes Forest Park	09.0194	079.5211	Yes
19	Clayton	09.0028	079.5872	Yes
20	Cerro Ancón	08.9553	079.5491	No
21	Balboa	08.9477	079.5549	No

The only vegetation available to the lizards were small patches of gardens and scattered trees (Fig. 2).

We set 14 transects along the city, 100 m long each, and used active visual search to find anoles (5 m/min.). All surveyed areas are within Panama City and are

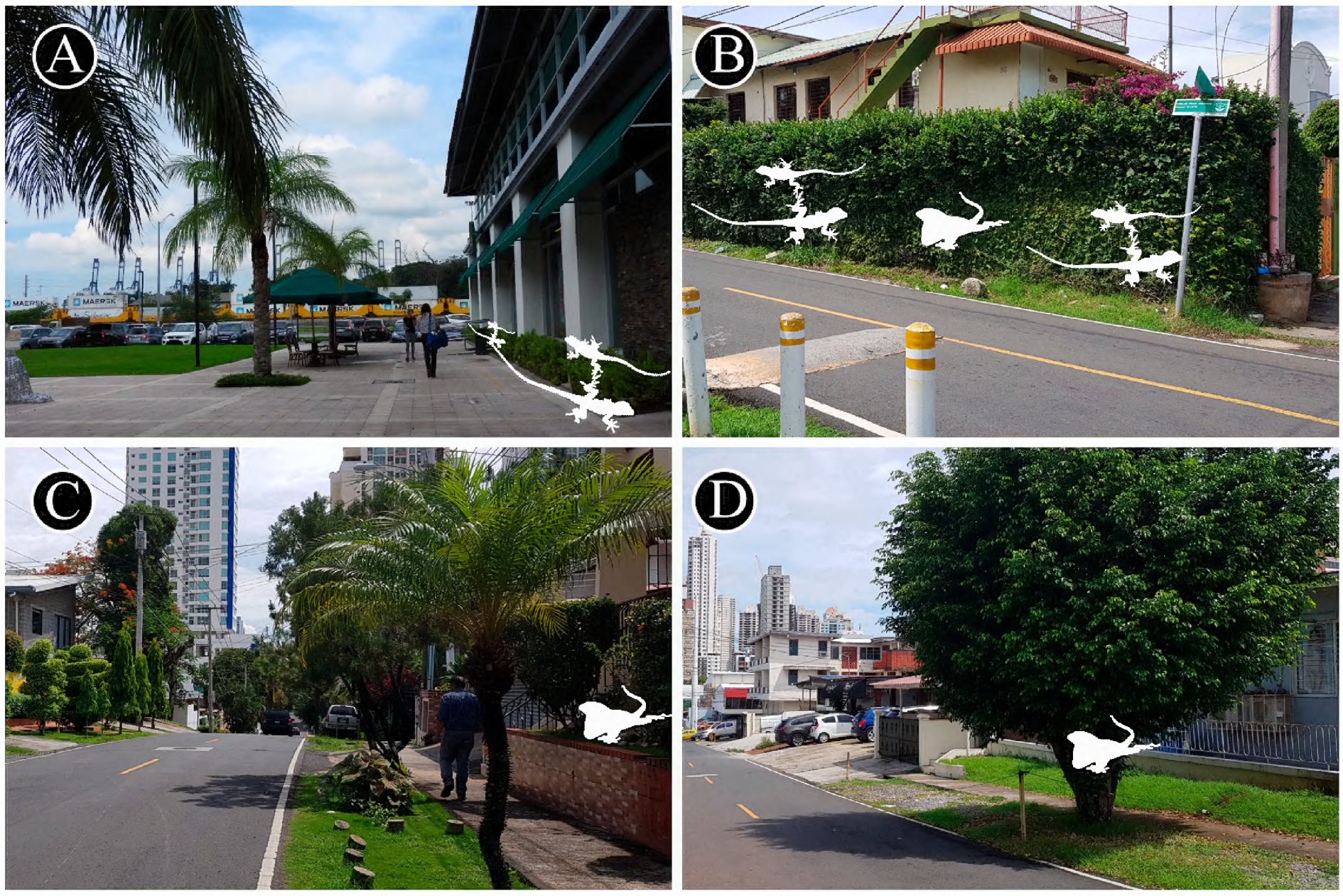

Figure 2. Habitat of *Anolis sagrei* in Panama City, Panama. **A.** Deli Gourmet Restaurant, Albrook, Balboa Port and Panama Canal Railway Company at background; **B–D.** Around 50th Street, downtown Panama City. White lizard images correspond to places where we found specimens.

surrounded by high traffic roads and buildings. All the specimens found were georeferenced using the WGS 1984 datum. A distribution map was created using QGIS (QGIS 2018) with an OSM layer (OSM contributors 2015). Collected specimens were euthanized with a pericardial injection of a euthanasia drug (T61), fixed using a solution of formalin (36%) and ethanol (94%, 1:200), stored in 70% ethanol, and deposited at the Museo Herpetológico de Chiriquí (MHCH), at the Universidad Autónoma de Chiriquí. All figures have been digitally improved and combined using Adobe Photoshop CS6. We described body colors based on photos of collected specimens in life. Snout-vent length and tail length measurements were taken using digital calipers. Terminology for morphometrics and pholidosis follows Köhler (2014). Collecting permit (SE/A-33-18) was provided by UNARGEN-Ministerio de Ambiente, Panama.

Results

Vouchered record. Panama, Panama province: Panama City: 67th Street East (08.9921° N, 079.5115° W), coll. by A. Batista, M. Ponce, M. Miranda, 22 May 2018 (MHCH 3223, 1 male).

This is the first record for the species in Panama.

Additional records. We found 25 specimens, 7 females (SVL= 50.67 mm ± 13.4, $n = 6$), 10 males (SVL= 42.67 mm ± 4.72, $n = 6$), 1 unmeasured juvenile, and 7 unsexed adults. In Albrook, we found 6 individuals basking in the border of planters (Fig. 2A). In a 30 min search at 50th Street (Fig. 2B–D), we found 11 individuals (4 males, 4 females, and 3 young). We collected one of them (MHCH 3223; Fig. 3) to confirm species identification. We found *A. sagrei* in 8 out of 14 transects, with an average of 1.6 individuals per transect. The minimum local range of *A. sagrei* in Panama City was estimated to be 28 km^2.

Identification. We identified *A. sagrei* based on the set of diagnostic characters proposed by Köhler (2008). This is composed of compressed tail, orange to red dewlap with a yellow margin and scales and enlarged post-anals. Sebastian Lotzkat confirmed the species identification.

Discussion

The origin of *A. sagrei* in Panama remains unknown, but 2 hypotheses are most likely: (1) via shipments arriving to the Port of Balboa, or (2) as captive individuals released around the city. Containers arriving at Balboa would be the most probable source of origin. However, as the *A. sagrei* occurs in the Caribbean islands and most ships arrive come from the Pacific, we can dismiss this possibility. Instead, containers carried by the trans-isthmian train coming from Cristobal, a Caribbean port in Colón, and subsequently taken to Balboa could be an option. One of the locations reported here is very close to the Port of Balboa, and one can even

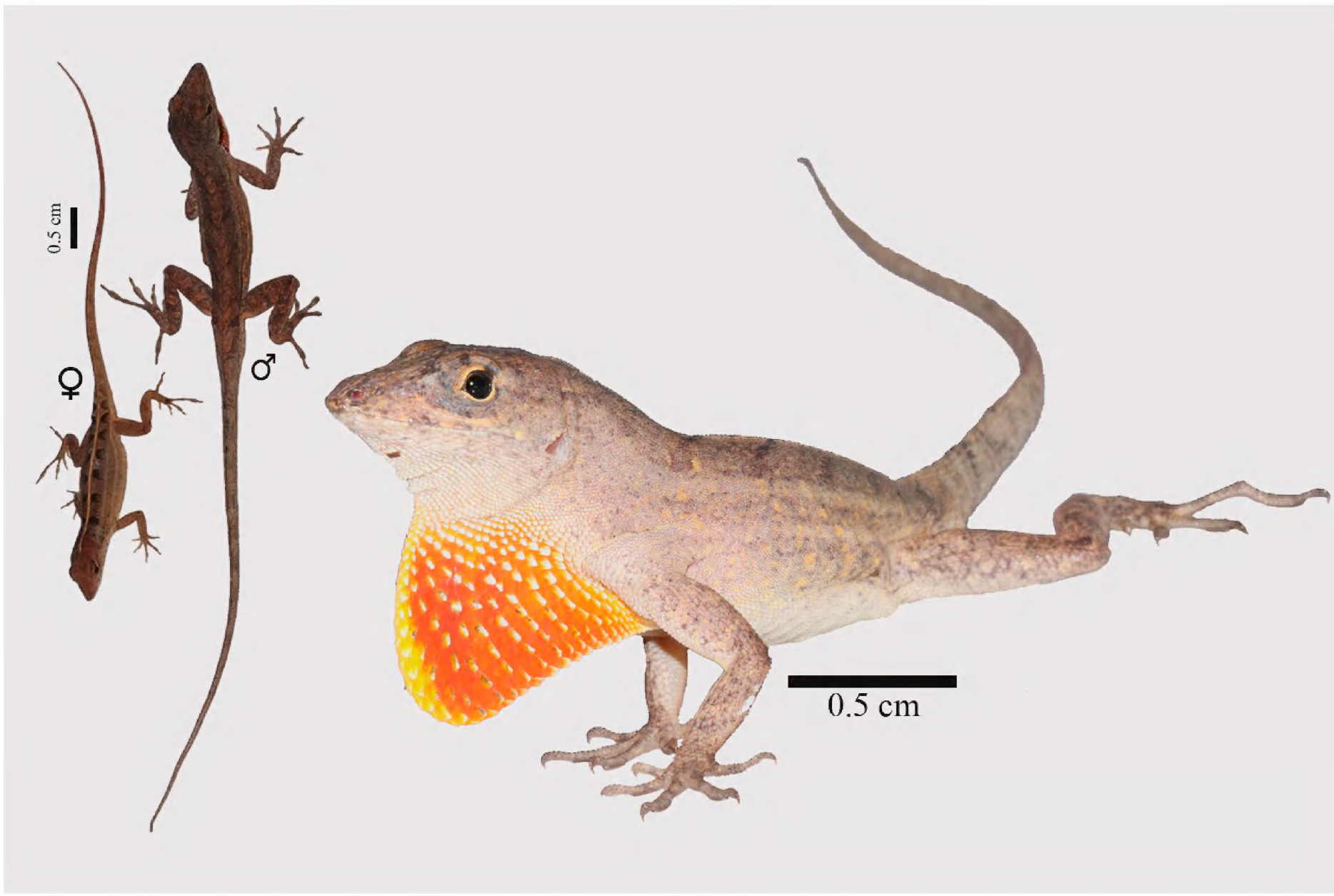

Figure 3. Two individual of *Anolis sagrei* found around 50th Street, downtown Panama City. Left: female and male (MHCH 3223), right: male (MHCH 3223).

see the trans-isthmian train from it (Fig. 2A). Captive released individuals around the city could also be a possible source of invasion. However, reptiles as pets are not common among Panamanians, and support for this hypothesis is weak.

Panama City is surrounded by natural protected areas, such as the Metropolitan Natural Park, which is very close to the locations in Albrook where we have found *A. sagrei*. The species mainly occupies open areas, it is highly territorial, and it can ecologically displace native species (Williams 1969). It is relatively well adapted to find food and avoid predators at newly colonized habitats (Schoener et al. 2017). Therefore, its capacity to displace other native species may be high. Native species such as *Gonatodes albogularis* (Duméril & Bibron, 1836) and *Anolis gaigei* (Ruthven, 1916), which are common around forest edges at the Metropolitan Natural Park and Cerro Ancón, could potentially be displaced by *A. sagrei*. Another concern is the species' potential of population growth at high densities of up to 0.97 lizards per m^2 (Schoener and Schoener 1980), contrary to Mesoamerican mainland species, for which densities do not exceed 0.14 lizards per m^2 (Sexton et al. 1963, Heatwole and Sexton 1966). We currently do not have evidence of native species displacement, and *A. sagrei* probably does not have any competitors, as native anoline lizards usually occupy habitats on the outskirts of the city. However, the presence of *A. sagrei* in Panama City is a potential threat to local species because *A. sagrei* could eventually share the same habitats along forest edges and, even more importantly, possibly transmit diseases or parasites to native species (Goldberg and Bursey 2000, Doan et al. 2019).

Anolis sagrei has a tremendous colonization capacity. It has recolonized 80% of the 50 islands in the Bahamas, 19 months after the islands being directly affected by the Hurricane Floyd (Schoener et al. 2001). This species could have become established in Panama at least 5 years ago and it was possibly misidentified as *A. tropidogaster* (Prof. Cambra pers. comm.). Additionally, the species may have been unnoticed in Panama City, because it can easily be confused with the native *A. gaigei* (C. Jaramillo pers. comm.). Distinguishing the species mainly relies on the smaller dewlap with a yellow margin (Köhler et al. 2012: fig. 3C, D), and compressed tail in *A. sagrei* (Köhler 2008; Köhler et al. 2012: figs 4F, 7C, D). *Anolis sagrei* also often occupies open and urbanized areas and shows behavioral repertoires that are not observed in *A. gaigei*, such as aggressive responses of males to approaching males or even females. *Anolis gaigei* is more secretive and it is mainly found in low semideciduous forests and bushy savannahs, usually on trees or fences enclosing cattle pastures. Estimates of population densities and long-term monitoring are required to refine the distribution of *A. sagrei* in Panama, as well as to assess dispersal rates and colonization routes. These studies should focus on the potential invasion of non-anthropogenic areas around Panama City.

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Authors' Contributions

AB, MP, OG and MM collected the data. AB and MP examined the specimens. AB and MM took the photographs and arranged table and figures. OG made transects and collected additional information. AB and MM wrote the text.

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